

## 2. STUDY METHODOLOGY

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The Alameda County CMP established that measurement of LOS be based on average travel speed, consistent with the method described in the "Manual of Traffic Engineering Studies"<sup>3</sup>. The study methodology involves establishing roadway segment boundaries, collecting travel time data, computing travel speeds, and comparing the average speeds with the LOS speed ranges as specified in the 1985 Highway Capacity Manual<sup>4</sup>. For this study, the "floating car" method was used to record travel times between roadway segments.

### DEFINITION OF ROADWAY SEGMENTS

The 230-mile Alameda County CMP was divided into approximately 290 segments for this study, using the methodology described below for the different roadway classifications.

#### Freeways

Major interchanges were used as the segment boundaries for freeways. Along more heavily traveled sections, the segments generally span from one to three interchanges. Where traffic volumes entering and exiting the freeway were minor, three or more sections were combined into longer segments. This is the case, for instance, in the eastern section of the I-580 corridor.

#### Arterials

For arterials, each section between two adjacent signals was first reviewed to determine its arterial class as Class I, II, or III. Arterial class is based on access control, land use intensity, free-flow speed, and other factors as defined in the 1985 Highway Capacity Manual (Chapter 11, pp. 11-1 to 11-4)<sup>5</sup>. Break points between segments generally occur at jurisdiction boundaries, at points where the number of travel lanes change, at major arterial street crossings, and at points where land use, speed limit, or canalization schemes change significantly. The segment boundaries for the arterial roadways are identical for both directions and the distances are generally the same or sufficiently close so as to be considered equal. Nevertheless, the distances for each direction of the same segment may differ somewhat in cases of very wide intersections.

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<sup>3</sup> Paul C. Box and Joseph C. Oppenlander, *Manual of Traffic Engineering Studies*, 4th ed. (Arlington VA.: Institute of Transportation Engineers, 1976).

<sup>4</sup> Transportation Research Board Special Report 209, *Highway Capacity Manual*, (Washington, D. C.: Transportation Research Board, 1985).

<sup>5</sup> Highway Capacity Manual, Special Report 209, a publication of the Transportation Research Board, Washington D.C., 1985

## LEVEL OF SERVICE SPEED STANDARDS

This study uses the LOS speed standards approved by the Alameda County CMA shown in Table 3 for arterials and freeways. The standards for other more unique types of roadway segments are described below.

### Rural Roadways

One of the CMP routes, State Route 84 from the southern city limit of Livermore to Mission Boulevard in Fremont, is a two-lane rural roadway, which requires a special analysis procedure. On this roadway, traffic and speed characteristics are fairly uniform. Variations in speed are a function of roadway curvature and the presence of slow trucks in the traffic stream. Based on suggested guidelines from the Highway Capacity Manual,<sup>6</sup> LOS "A" is deemed to occur when vehicles are traveling at a free flow speed for the given roadway conditions. Special studies were conducted in the 1992 surveys during off-peak, low-volume conditions to document the free flow speed. LOS "F" is estimated to occur when speeds have dropped below 50 percent of the free flow speeds. Levels of Service "B" to "E" are calculated at even intervals between free flow speeds and LOS "F" speeds.

### Freeway-to-Freeway and State Route-to-Freeway Ramps

Separate travel time/speed runs were conducted for the ramps at freeway-to-freeway interchanges, since these connections can frequently have very different characteristics than the freeways themselves. The guidelines for establishing LOS were similar to those used for rural highways. LOS "A" is deemed to occur when vehicles are traveling at the free flow speeds for the given roadway conditions. Special studies were previously conducted as a part of the 1992 studies, during off-peak low-volume conditions, to document free flow speeds. Per the suggested guidelines of the Highway Capacity Manual, LOS "F" occurs when speeds drop below 50 percent of the free flow speeds. Levels of Service "B" to "E" are calculated at even intervals between free flow speeds and LOS "F" speeds. The ramp locations that have been studied for the 2004 LOS study are the following:

- 1.) I-80 to I-580 connections (Oakland-Emeryville area)
- 2.) I-580 to SH 24 connections (Oakland)
- 3.) SH 13 to SH 24 connections (in the vicinity of the Caldecott Tunnel, Oakland)
- 4.) I-880 to I-238 connections (San Leandro)
- 5.) I-238 to I-580 connections (Hayward)
- 6.) I-580 to I-680 connections (Pleasanton)
- 7.) I-880 to SH 260 connections (at the Alameda tubes, Oakland)

<sup>6</sup> Highway Capacity Manual, Special Report 209, a publication of the Transportation Research Board, Washington D. C., 1985.

**Table 3**  
**Relationship between Average Travel Speed and Level of Service**  
**Alameda County Congestion Management Agency**

**Levels of Service for Freeway Sections<sup>7</sup>**

LOS	Density (pc/mi/ln) <sup>8</sup>	Speed (mph)	Volume/Capacity Ratio	Maximum Service Flow (pcphpl) <sup>9</sup>
A	≤ 12	≥ 60	0.35	700
B	≤ 20	≥ 55	0.58	1,000
C	≤ 30	≥ 49	0.75	1,500
D	≤ 42	≥ 41	0.90	1,800
E	≤ 67	≥ 30	1.00	2,000
F	> 67	< 30	--- <sup>10</sup>	---

**Range for Level of Service F for Freeway Sections<sup>11</sup>**

F30 – Average Travel Speed <30

F20 – Average Travel Speed <20

F10 – Average Travel Speed <10

**Arterial Levels of Service<sup>12</sup>**

Arterial Class	I	II	III
Range of Free Flow Speeds (mph)	45 to 35	35 to 30	35 to 25
Typical Free Flow Speed (mph)	40 mph	33 mph	27 mph
Level of Service	Average Travel Speed (mph)		
A	≥ 35	≥ 30	≥ 25
B	≥ 28	≥ 24	≥ 19
C	≥ 22	≥ 18	≥ 13
D	≥ 17	≥ 14	≥ 9
E	≥ 13	≥ 10	≥ 7
F	< 13	<10	<7

<sup>7</sup> Adapted from Table 4-1, Special Report 209, Highway Capacity Manual; 1985.

<sup>8</sup> Passenger cars per mile per lane.

<sup>9</sup> Maximum service flow under ideal conditions, expressed as passenger cars per hour per lane.

<sup>10</sup> Highly variable, unstable flow; V/C Ratio is not applicable.

<sup>11</sup> Approved by Plans and Programs Committee of the ACCMA on June 14, 2004 to show degrees of LOS F on congested roadways

<sup>12</sup> Table 12-1, Special Report 209, Highway Capacity Manual, 1985. For Rural Roadways, refer to Table 8-1 in the Highway Capacity Manual.

## DATA COLLECTION

Travel time data was collected for all segments on the CMP network during the period from April 5, 2004 through June 17, 2004. Travel time runs were made during the afternoon peak hours of 4:00 to 6:00 P.M. In addition, runs were made during the A.M. peak period (7:00 to 9:00 A.M.) on selected critical segments. Consistent with the CMP guidelines, all runs were made on a Tuesday, Wednesday, or Thursday.

The travel time runs were spread evenly throughout the two-hour period. For each travel time run, the actual clock time was recorded as the test car passed the checkpoint. The travel times between checkpoints were then computed as the difference between the two corresponding clock times.

For the majority of the CMP system, at least six runs were made on each roadway segment. More than six runs were made on some LOS "E" and "F" segments where heavy congestion has been previously reported where a greater range of fluctuation in travel speed was found, or where questionable data was reported. On certain routes where free flow conditions of LOS "C" or better were experienced in 2002 and where this data is consistent with previous reports, the studies were sometimes concluded after four runs were completed. The number of runs that were conducted on each route and the times and dates of the runs are included in the *Technical Compendium*, which is available for review at the ACCMA.

## Construction Activities and Improvements

Several CMP roadway segments were under construction during the 2004 study period, and the travel time/speed data on these routes could be considerably different than normal average traffic conditions. When the travel time runs were conducted (April-June, 2004), there was construction on the Bay Bridge, SR 238/Mission between Mowry Avenue and Niles Canyon Road, Atlantic Avenue between West Campus Drive and Main Street (lane closures in both directions), and University Avenue (median work and lane closures in the eastbound direction). Alameda County informed that there was construction of LAVWMA project. At several locations, there may have been construction occurring along the edge of the roadway, but it was judged that the construction did not have a significant impact on the travel time results.

Some roadway improvements were completed since the 2002 surveys. On I-680 southbound in the Tri-Valley a carpool lane and auxiliary lane have been added. On San Mateo Bridge (SR 92) one additional lane in each direction has been added making the four-lane bridge to a six-lane bridge. On the eastbound SR 92 four lanes exit the bridge and then narrows down to three. As a result of the freeway construction at the I-580/I-680 Interchange, the distances between ramps changed. These ramp-to-ramp distances were checked and revised.

SR 84 in Livermore has been realigned in December 2003 along Isabel Parkway, Kitty Hawk Road and Airway Boulevard to connect to I-580, after the construction of Isabel Parkway. Accordingly, the 2004 LOS Monitoring Study includes the realigned SR 84 replacing the old SR 84 alignment along Holmes Street and 1<sup>st</sup> Avenue to connect to I-580.

## DATA ANALYSIS PROCEDURES

The travel speeds have been determined using the measured times and the distances between the checkpoints. The section-by-section and run-by-run travel time and speed data were checked for errors and abnormal results. Mathematically, the average travel time for a segment was computed as the sum of the average travel times of the individual sections comprising the segment. The average travel speed has been determined by dividing the average travel time for the segment into the segment length. For a more complete discussion of study methodology, see the description that was included in the initial study for establishing the existing Level of Service<sup>13</sup>.

The LOS results represent the average travel time during the two-hour peak periods on an average weekday. For many roadway segments, the range of measured speeds is very constant throughout the two-hour period. For others, the travel times within this period can be quite different, especially when the peak congestion lasts for less than two hours.

For arterials, the travel time results are closely related to (1) traffic signal timing, and (2) the vehicle location in the traffic platoon during the study. In analyzing the data, if a travel time run was made at the very beginning of the two-hour period, or toward the end of the period, and the data point was significantly different than other runs, this data point was discarded. Additional travel time runs were then made during the time period when traffic congestion was more severe.

Some special conditions exist on freeway segments in the vicinity of major off-ramps. There may be different speeds in each lane of the freeway if the rightmost lanes are affected by congestion in the off-ramp. At some of the freeway-to-freeway interchanges on the CMP network, drivers may experience a different LOS in the rightmost lane or on the ramp connection than on the freeway itself. In this study, separate travel time/speed runs were made for ramps since these connections can frequently have very different characteristics from the freeways themselves. However, no separate travel time/speed runs were made for the rightmost lanes of the freeways approaching ramps. For example, LOS "F" conditions were not measured on I-880 northbound at I-238 based on traffic flow in the center lanes (consistent with the data collection methodology), nor were LOS "F" conditions measured on the connector ramp itself (beyond the gore point) from northbound I-880 to I-238, although drivers in the rightmost lane on northbound I-880 often experience significant congestion approaching the I-238 off-ramp. This may also be occurring at the I-580/I-680 interchange.

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<sup>13</sup> Abrams Associates, "Establishing the Existing Level of Service for the Alameda County CMP Designated Roadway System," November 26, 1991.